Characterization technique:
Transmission Scanning Electron Microscopy (TSEM)

Outlines:

1. Introduction
2. Structure and different components of TSEM
3. Working of TSEM
4. Applications

Prerequisite/Recapitulations

Knowledge of basics of quantum mechanics

Objectives

After the completion of this lecture, you will be able to:

1. Understand the structure of TSEM
2. Learn the different components and working of TSEM

Introduction

Transmission Scanning Electron Microscope (TSEM)

TESM will yield the following information:

- **Morphology**

  The size, shape and arrangement of the particles which make up the specimen as well as their relationship to each other on the scale of atomic diameters.

- **Crystallographic Information**

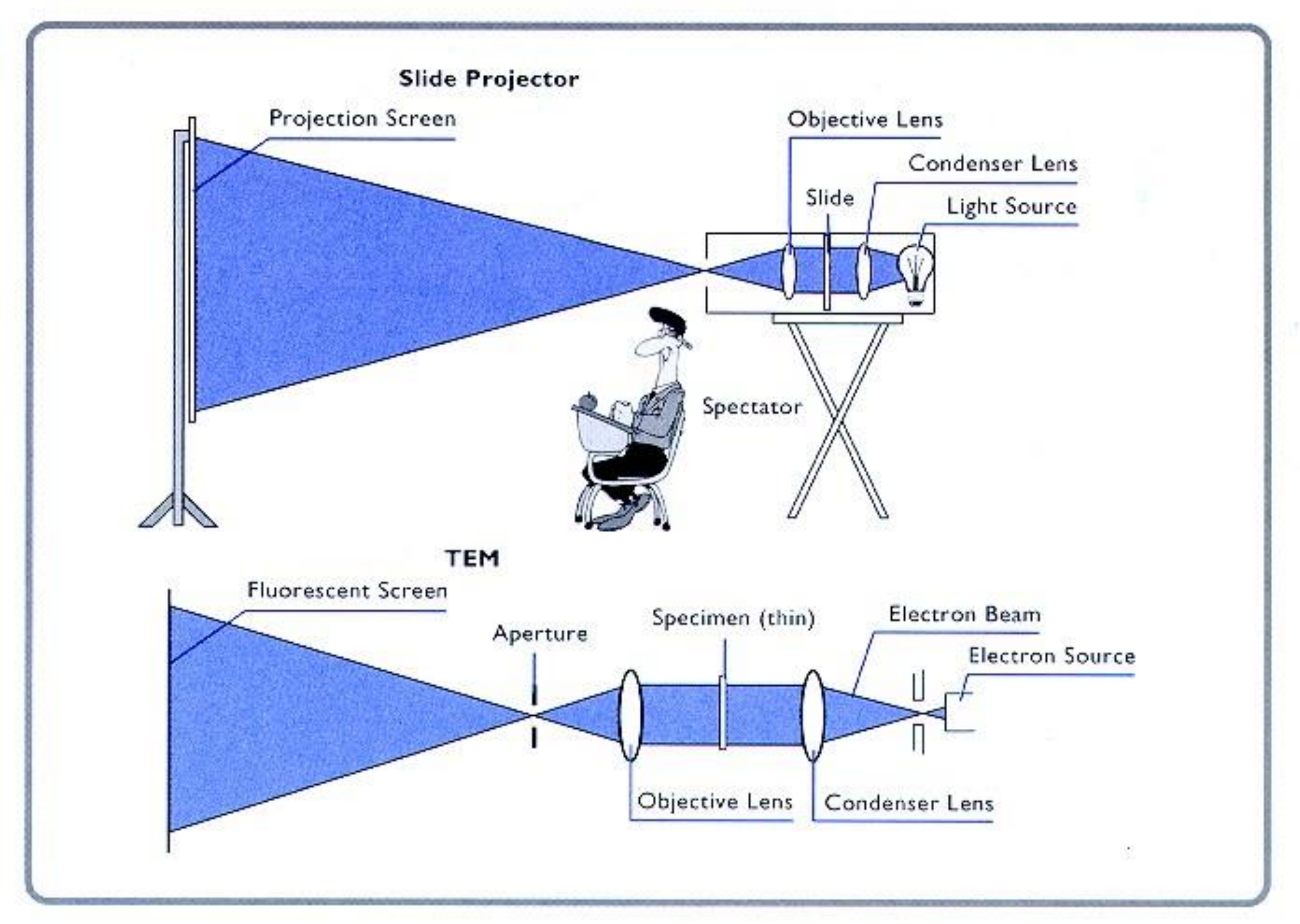
  The arrangement of atoms in the specimen and their degree of order, detection of atomic-scale defects in areas a few nanometers in diameter

- **Compositional Information (if so equipped)**

  The elements and compounds the sample is composed of and their relative ratios, in areas a few nanometers in diameter

Transmission Scanning Electron Microscope (TSEM)

A transmission Scanning Electron Microscope is anologous to a slide projector as indicated



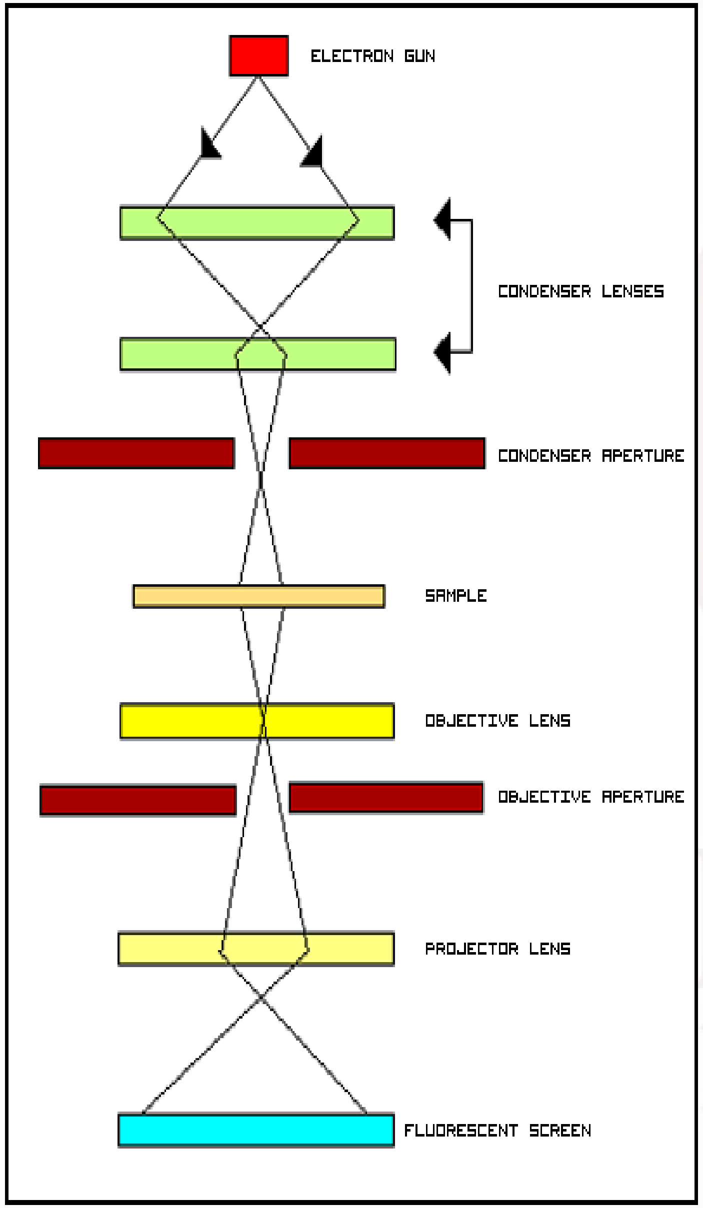
Transmission Scanning Electron Microscope (TSEM)

In a conventional transmission electron microscope, a thin specimen is irradiated with an electron beam of uniform current density. Electrons are emitted from the electron gun and illuminate the specimen through a two or three stage condenser lens system. Objective lens provides the formation of either image or diffraction pattern of the specimen. The electron intensity distribution behind the specimen is magnified with a three or four stage lens system and viewed on a fluorescent screen. The image can be recorded by direct exposure of a photographic emulsion or an image plate or digitally by a CCD camera.

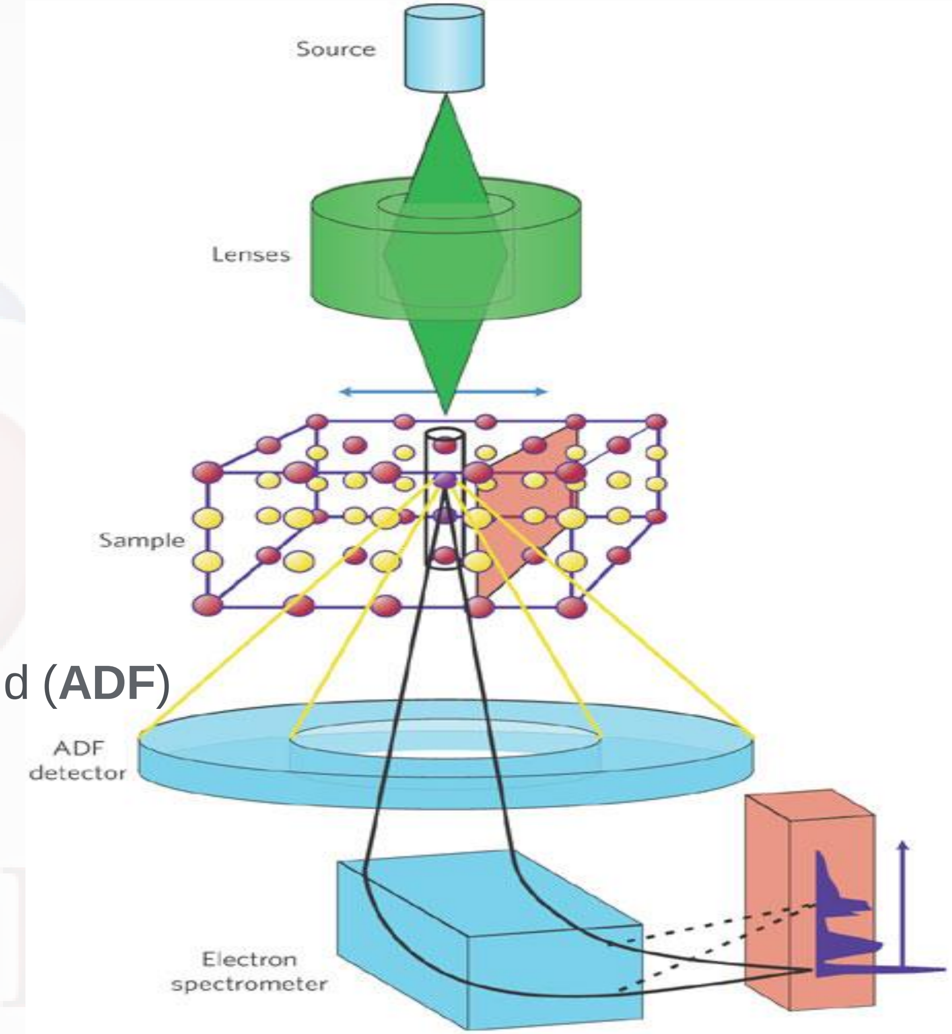
The acceleration voltage of up to date routine instruments is 120 to 200 kV. Medium-voltage instruments work at 200-500 kV to provide a better transmission and resolution, and in high voltage electron microscopy (HVEM) the acceleration voltage is in the range 500 kV to 3 MV. Acceleration voltage determines the velocity, wavelength and hence the resolution (ability to distinguish the neighbouring microstructural features) of the microscope. Depending on the aim of the investigation and configuration of the microscope, transmission electron microscopy can be categorized as :

Conventional Transmission Electron Microscopy
High Resolution Electron Microscopy
Analytical Electron Microscopy
Energy-Filtering Electron Microscopy
High Voltage Electron Microscopy
Dedicated Scanning Transmission Electron Microscopy

Structure of Transmission Scanning Electron Microscope (TSEM)

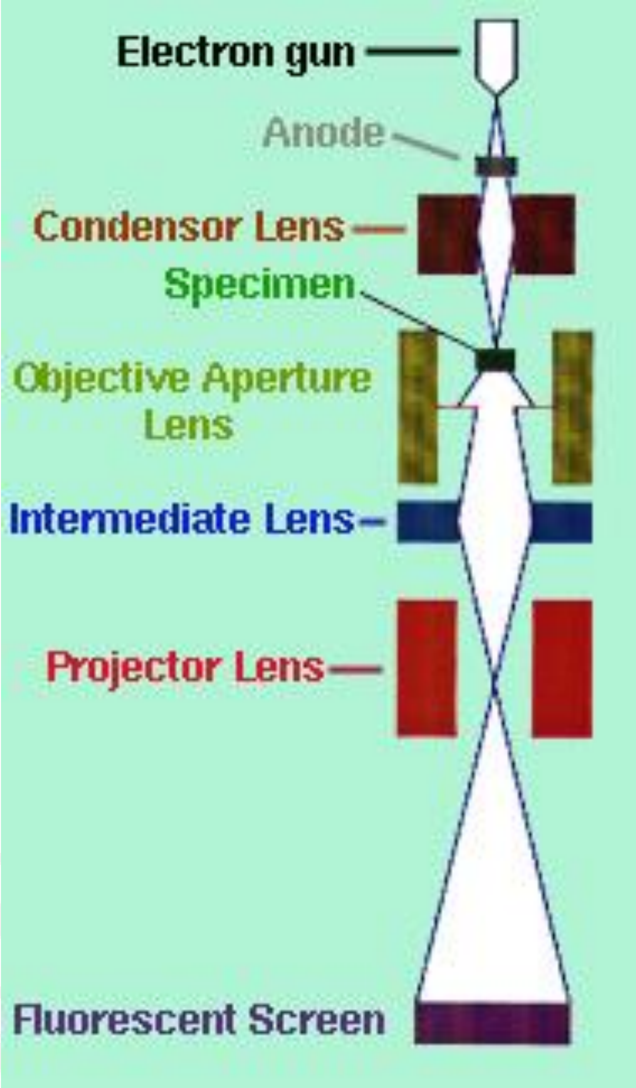


annular dark-field (**ADF**)

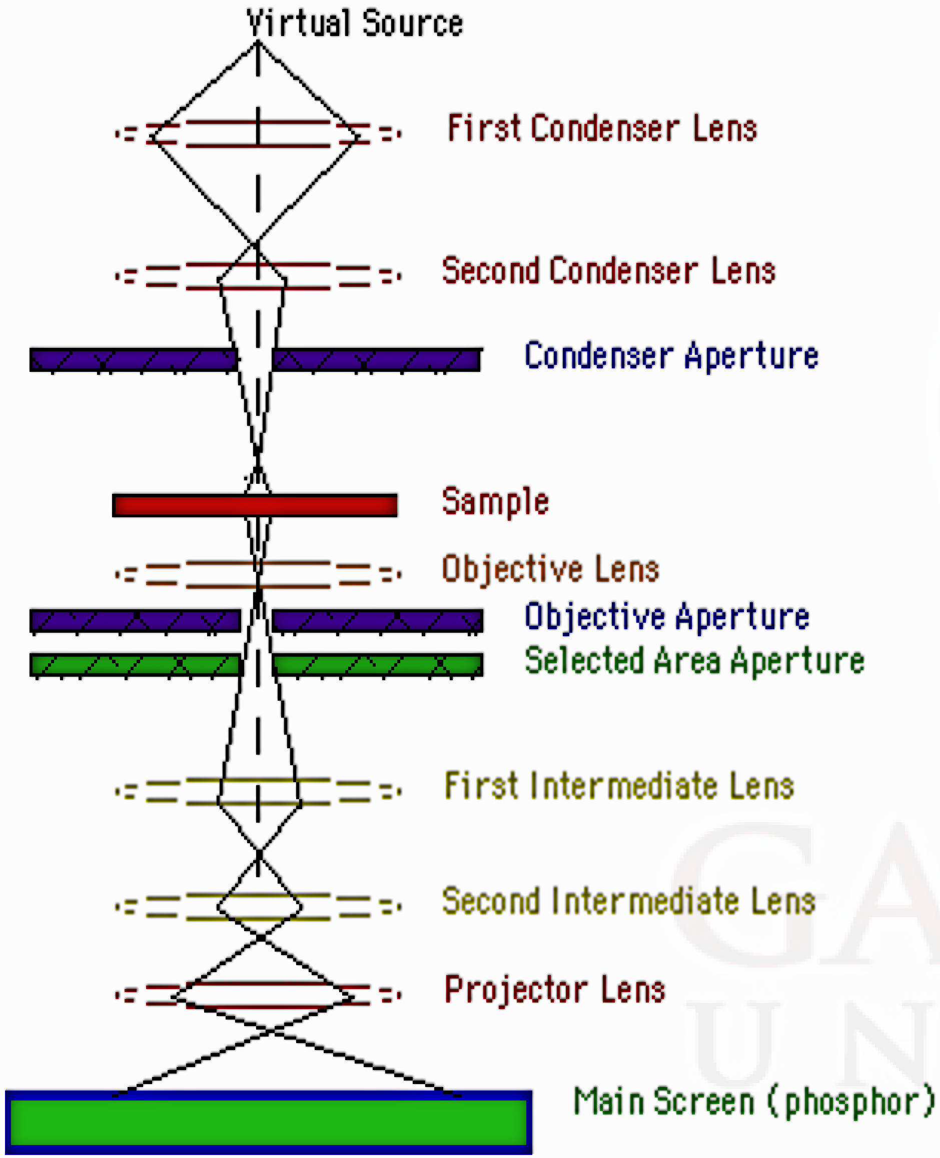


Working of Transmission Scanning Electron Microscope (TSEM)

- Gun emits electrons
- Electric field accelerates
- Magnetic (and electric) field control path of electrons
- Electron wavelength @ 200KeV ≈ $2x10^{-12}$ m
- Resolution normally achievable @ 200KeV ≈ 2×10^{-10} m ≡ 2Å

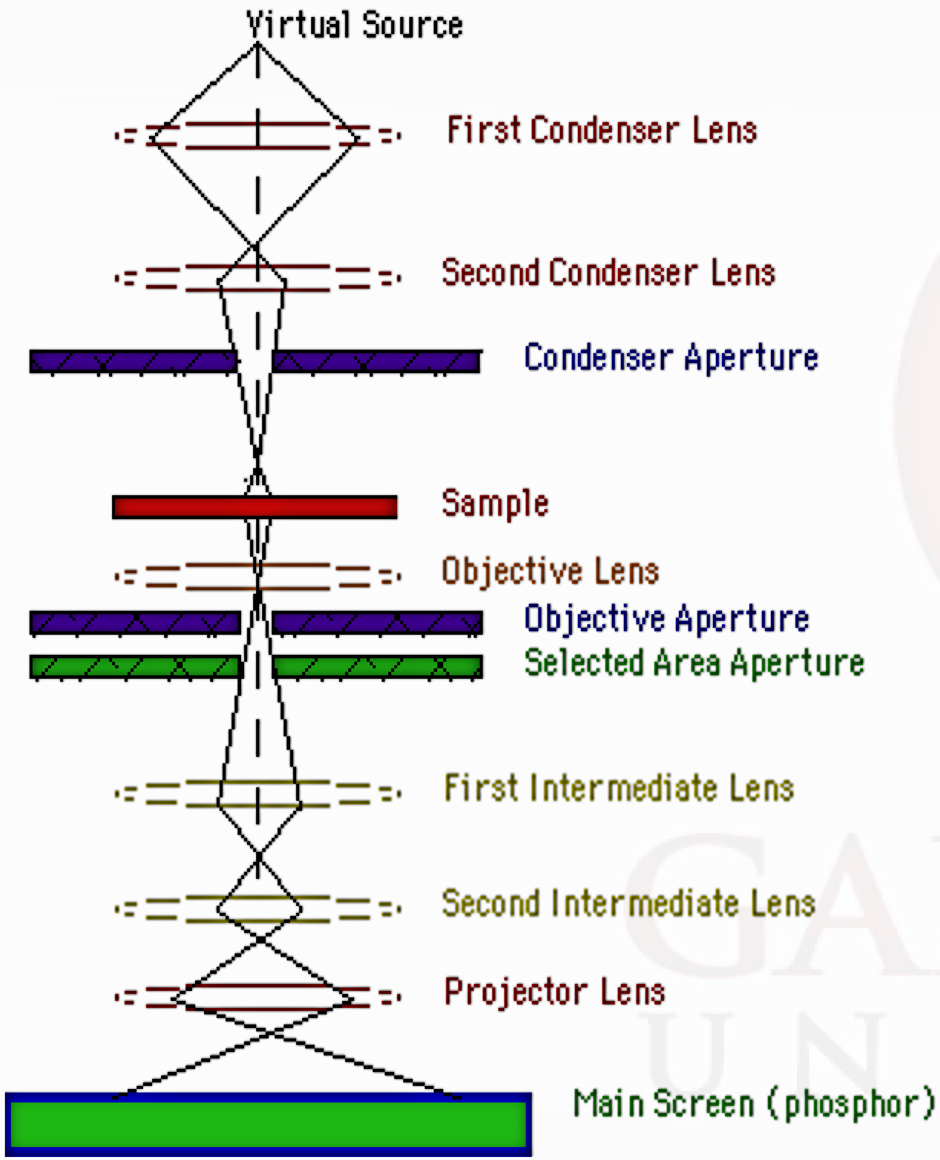


Working of Transmission Scanning Electron Microscope (TEM)



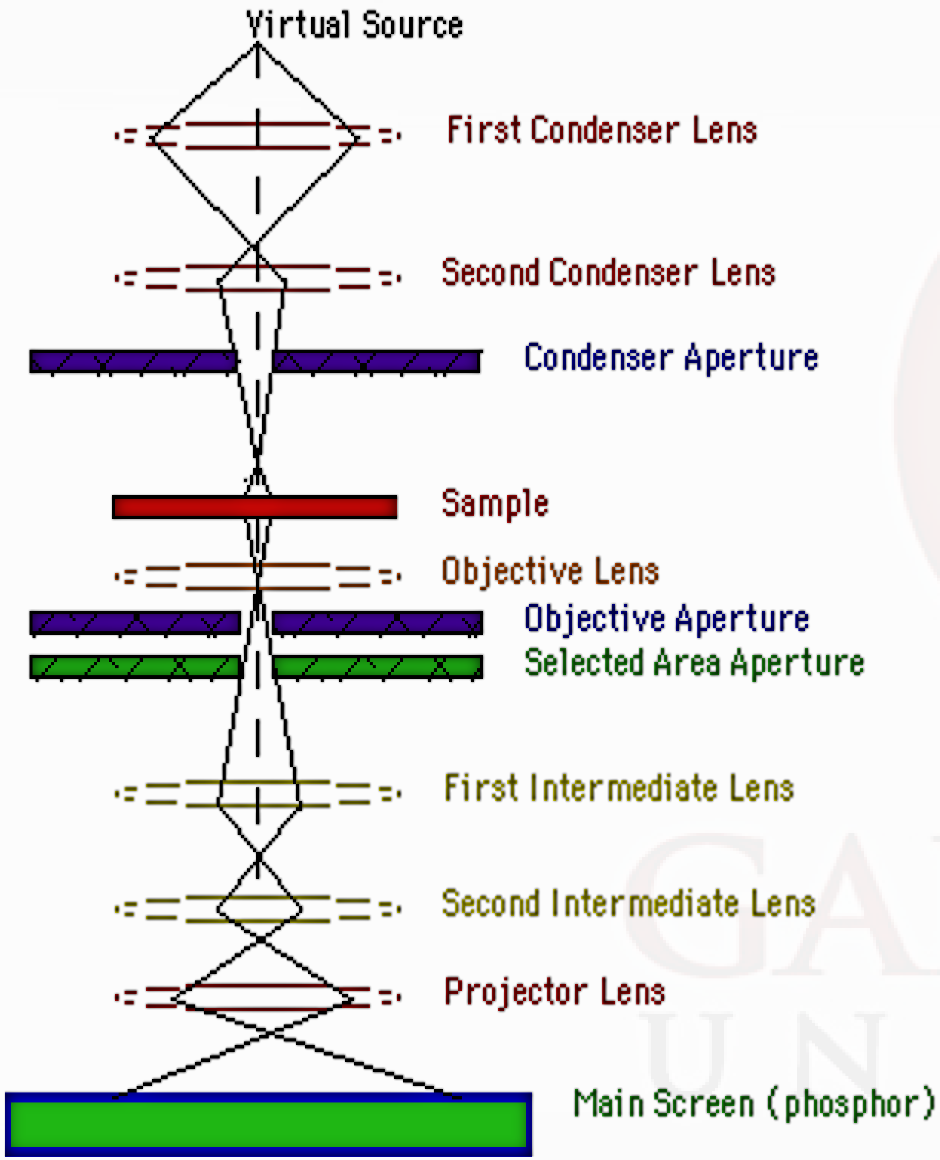
1. The "Virtual Source" at the top.
2. This stream is focused to a small, represents the electron gun, producing a stream of monochromatic electrons thin, coherent beam by the use of condenser lenses 1 and 2.
3. The first lens(usually controlled by the "spot size knob") largely determines the "spot size"; the general size range of the final spot that strikes the sample.
4. The second lens(usually controlled by the "intensity or brightness knob" actually changes the size of the spot on the sample; changing it from a wide dispersed spot to a pinpoint beam.

Working of Transmission Scanning Electron Microscope (TSEM)



5. The beam is restricted by the condenser aperture (usually user selectable), knocking out high angle electrons (those far from the optic axis, the dotted line down the center)
6. The beam strikes the specimen and parts of it are transmitted
7. This transmitted portion is focused by the objective lens into an image.
8. Optional Objective and Selected Area metal apertures can restrict the beam; the Objective aperture enhancing contrast by blocking out high-angle diffracted electrons, the Selected Area aperture enabling the user to examine the periodic diffraction of electrons by ordered arrangements of atoms in the sample

Working of Transmission Scanning Electron Microscope (TSEM)



9. **The image is passed down the column through the intermediate and projector lenses, being enlarged all the way**

10. **The image strikes the phosphor image screen and light is generated, allowing the user to see the image. The darker areas of the image represent those areas of the sample that fewer electrons were transmitted through (they are thicker or denser). The lighter areas of the image represent those areas of the sample that more electrons were transmitted through (they are thinner or less dense)**

Sample preparation

In a TEM, the specimen you want to look at must be of such a low density that it allows electrons to travel through the tissue. There are different ways to prepare your material for that purpose. You can cut very thin slices of your specimen from a piece of tissue either by fixing it in plastic or working with it as frozen material. Another way to prepare your specimen is to isolate it and study a solution of for example viruses or molecules in the TEM.

You can also stain the specimen in different ways and use markers to locate specific things in the tissue. It can for example, be stained with heavy metals like uranium and lead, which scatters electrons well and improves the contrast in the microscope.

Applications

TEM is used in a wide variety of fields From Biology, Microbiology, Nanotechnology, forensic studies, etc. Some of these applications include:

1. To visualize and study cell structures of bacteria, viruses, and fungi
2. To view bacteria flagella and plasmids
3. To view the shapes and sizes of microbial cell organelles
4. To study and differentiate between plant and animal cells.
5. Its also used in nanotechnology to study nanoparticles such as ZnO nanoparticles
6. It is used to detect and identify fractures, damaged microparticles which further enable repair mechanisms of the particles.

Comparisons in characterization techniques

Pros and Cons

	Compound Light Microscope	Scanning Electron Microscope	Transmission Electron Microscope
+	has two systems of lenses for greater magnification (eyepiece lens and objective lens)	has a large depth of field – allows much more of a specimen to be in focus at one time	can magnify objects up to 1,000,000 times
+	eyepiece has achromatic doublet lens;appears to have a bigger hole to look through, so easier to use	produces images of greater resolution	great depth of field ensures that the images are very sharp
-	cannot magnify more than 2000X	cannot produce color	cannot view living specimens because this microscope involves high-energy particles
-	cannot view viruses, molecules, and atoms	as the resolution increases, the field of view decreases - becomes very difficult to view the molecular detail within the cell	image brightness is low

Questions

Explain the basic principle of TSEM
Explain the working of TSEM
What are the applications of TSEM?
What are the basic components used to design the TSEM?

References

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